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ABSTRACT

Geographers in the United States rely heavily on microcomputers. They employ microcomputers to enhance three general categories of tasks: word processing and other productivity needs, geographic instruction, and discipline-specific applications. Word processing and desktop publishing continue to be the primary uses of microcomputers by geographers. Creation of charts and graphs is common, and increasingly, spreadsheets, database management systems, and gradebook programs are being used. The effectiveness of instruction using computers is difficult to determine as the medium is relatively new and evolving rapidly. Computer-assisted instruction and computer-assisted learning are discussed, as are examples of each: tutorials, simulations, games, and databases. Microcomputer uses essentially unique to geography include the acquisition and display of digital data, digital image analysis, computer mapping, geographical information systems (GIS), and statistical analysis of spatial problems. Software packages are described for applications such as digitized XYZ terrain data, databases, statistics, digital satellite image analysis, computer cartography, GIS, and spatial analysis. Four examples of computer-generated contour maps and demographic maps are presented. Geographers must be active participants in the development of geographic software. Geographic curriculum should incorporate more computer training so students can go beyond the boundaries of users and become developers. Unless geographers become developers, geographic software will be produced by others, thereby limiting geographers' control over content and quality. A 20-item bibliography is included. (GEA)

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MICROCOMPUTERS IN GEOGRAPHY

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Microcomputers in Geography

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Assn. of American Geographers Microcomputer Specialty Group

Introduction

The Microcomputer Specialty Group is unique among the specialty groups in the AAG. We are the only specialty group that has as its central focus a widely-used tool rather than a specific disciplinary content. For that reason, we share many functions with microcomputer users in general. Although that is true, this presentation will focus mostly upon the uses of microcomputers as they relate to geographic applications.

AAG specialty groups are only a few year old. However, most specialty groups are based upon sub-fields within geography that have existed for a long time. We are different in that respect, for even if we had wanted to exist 10 or 15 years ago it would not have been possible. The first mass-produced, user-oriented microcomputers only came on the market in 1977. In that year Apple and Commodore began the microcomputer revolution. Although the Apple II was generally accepted in elementary and secondary schools within a couple of years of its introduction, university acceptance of it was spotty at best.

Then, in 1981, IBM introduced the PC, based on the Intel 16 bit 8088 microprocessor. This machine was not particularly revolutionary in its design, but it offered an open architecture and a flexible operating system that enabled third party vendors to easily create software and add-in hardware. The IBM-PC served to legitimize microcomputers. With its introduction, microcomputers spread throughout higher education and the business world in general. It was in that environment that the Microcomputer Specialty Group was organized.

Since those early days, it can be argued that three major developments in microcomputers have occurred.

First, Apple introduced the Macintosh in January, 1984, a scaled down and lower cost version of its ill-fated Lisa. The original Macintosh was faster than the IBM-PC and offered better graphics, although they were not in color. It ran on a Motorola 68000 microprocessor and used a common interface for all its software that was intuitively easy to learn, but it lacked an open architecture, and it was not compatible with the IBM computers.

Second, in 1984, IBM speeded up its micros and enhanced its graphics with the introduction of AT machines with Enhanced Graphics Adapters (EGA). These machines employed the next generation of Intel microprocessors, the 80286. Open architecture was still a feature of these machines. They were downward compatible with the older IBM micros, and just as the earlier IBM machines were cloned by multiple vendors so were these machines.

The third and most recent break-through has occurred on two fronts. Intel and Motorola introduced true 32 bit microprocessors in 1986. The Intel 80386 is incorporated into some of the new IBM System 2 computers and in numerous microcomputers by independent producers; chief among them are the new Compaq micros. The Motorola 68020/68030 is the heart of the new MacIntosh II. Both the MacIntosh II and the IBM System 2 computers came on the market in 1987.

We now are at the beginning of a period in which microcomputer speeds and capacities have increased at phenomenal rates. We now have the capacity to perform many numeric intensive operations that formerly could only be done on mini and mainframe computers. However, one "fly" has become entrapped "in the ointment." In the heyday of the IBM-PC/XT/AT, microcomputers became essentially standardized on the MS-DOS operating system. (Apple did not follow the standard.) At present, no standard exists on the newest machines. This means that creating software may be more difficult and add-in enhancements may not be as easy to achieve as in the past. We stand at a crossroad, but the future still is bright.

Extent of Use

Geographers in the United States rely heavily on microcomputers. They are popular because of their capabilities: they give us the power to accomplish much work at high speed. Moreover, they are affordable. Their portability is important to a field-oriented discipline such as ours. In addition, we see their potential to enhance our teaching. We recognize that they motivate students because they are tirelessly interactive, give personal responses, and provide immediate feedback on performance.

We might make even greater use of microcomputers if prices were to drop further, if software quality were better, if we could solve the liveware problem (the need to staff microcomputer laboratories), and if we could find sufficient time to learn new applications and to convert from manual systems to automated setups. Some geographers find that the problem of acquiring computer skills is as serious a constraint to use as any of the others listed.

How We Use Microcomputers

Geographers employ microcomputers to enhance three general categories of tasks. First, geographers must perform chores that are not essentially geographic. We use a variety of "productivity" programs to help us with these chores. Second, we teach. Much software is available to help with geographic instruction. Third, we can identify geographic applications that are essentially unique to the discipline. For an early review of these applications, we recommend the article by Anthony Gar-On Yeh (1986).

Shared Uses That Increase Productivity

Word processing continues to be the number one use of microcomputers by geographers. Desktop publishing has evolved from

word processing. It is a recent development that will grow in importance in academic institutions. Spreadsheet, database management and gradebook programs are also used frequently by geographers to increase productivity. When combined with the new, light-weight laptop computers, users can employ database and spreadsheet programs to record and manipulate data in the field. Microcomputers also open up potentially unlimited online database resources for us. With a modem and the proper telecommunication software, access to remote databases is easy. We can use the same equipment and software to communicate or to transmit data through commercial networks such as Compuserve, and educational networks such as BITNET.

Another common use of microcomputers is the creation of charts and graphs by presentation graphics software. Geography has always been a very visual science; presentation graphics can help geographers get their message across in the classroom or whenever they present papers at professional meetings.

Using Microcomputers for Geographic Instruction

Assessing the effectiveness of instruction using computers is difficult because the medium is still quite new and the quality of software is evolving rapidly. Early computer assisted instruction (CAI) used rudimentary and unimaginative drill-and-practice routines. Today, better software is beginning to appear. In fact, a distinction should now be drawn between computer-assisted instruction (CAI) and computer-assisted learning (CAL), which is characterized by a degree of flexibility, interaction, and student-initiated activity which is absent in its more formalized predecessor.

CAI/CAL

An examination of the types of CAI/CAL and a look at a number of specific software programs should serve to illuminate both the potential advantages and limitations of computers in the geography classroom. The software evaluations of EPIE (Educational Products Information Exchange) are another source of worthwhile information.

The earliest, and still the most common type of CAI software, drill and practice, focuses on learning at the lower cognitive levels of factual knowledge and memorization. Strictly speaking, drill and practice is not for initial learning but rather for reinforcement through practice of material learned elsewhere. Although there is clearly a place for drill and practice programs, all too often they are tedious and ineffective.

Unfortunately, many CAI/CAL programs that find their way to the schools consist of nothing but text. They include no graphics, bludgeoning the student instead with an interminable list of factual questions such as: "The capital of Iowa is: (Type the letter from the choices below and press RETURN)...."

Several design features can enliven drill and practice programs. User selectable levels of difficulty are helpful. Based on each student's performance, as "evaluated" by the software, a program may

branch forward to more advanced material or backward to permit review of material. Various kinds of stimuli and responses can be employed besides written questions requiring a single keystroke answer. "Hybridized" drill and practice programs are effective, incorporating elements of a game or simulation to motivate students.

Tutorials

Many easy-to-produce, rather banal "page-turning" tutorial programs followed on the heels of the early drill and practice programs. Unfortunately, too many are still around. Typically a program presents a student with a segment of verbal information, usually with accompanying illustrative graphics, then he/she is asked to respond to a question, which then leads to the next segment, and so forth. Branching is possible to some degree, although it is usually important that all steps in the instructional sequence are covered in order. If this sounds somewhat like reading a textbook or listening to a well-illustrated lecture, your perception is correct. It is difficult to see the advantage of such programs over books.

Software producers have gradually come to agree that the place for tutorials is within other kinds of programs more suited to the capabilities of the computer. For instance, tutorials are often included as "help screens" in simulation/games, elucidating difficult material or providing supplementary material.

Simulations

Simulation software programs model a real or imaginary system according to certain logical rules of operation. Simulations may be open-ended and highly individualized in that the outcome of the simulation depends on the particular input of the specific player (or players in the case of multi-player or team programs). Learning outcomes are hard to predict and learning objectives may read more like general goals. Role-playing simulations focus on higher-order cognitive processes such as analysis, synthesis, comprehension, and comparison. Role-playing is often an excellent means of attaining affective objectives as well. Clearly simulations are categorized more properly as CAL than CAI.

Some excellent simulation software exists which deals with topics in human and physical geography, usually for high school or college levels. For example, in the program called *Rice Farming* (1983) students become rice farmers in India, confronting Third World problems in economic geography. In another program, *Simpolicon* (1983), players must make decisions about allocating limited resources (mineral wealth, land, hand-tools, unskilled labor) to promote economic development in a hypothetical country while preserving long-term environmental quality, all in a competitive situation. In one physical geography simulation, students play the roles of volcanologists and seismologists. They predict likely eruptions after studying on-screen databases and conducting various simulated tests, while carefully managing their allotted budgets (*Volcanoes*, 1982). A similar program, called *Geoworld* (1986), requires students to explore the world for mineral resources after consulting both

on-screen and printed reference data in addition to conducting geological tests.

Games

Perhaps the most significant piece of geographic software of all time is *Where in the World is Carmen Sandiego?* (Broderbund, 1985.) More copies of this package for the Apple II computer have been sold than any other geography program ever written. Unfortunately, geographers played no significant role in the creation of this software. Maybe we can learn a lesson from this.

Data Bases

Although simulation programs may passively consult databases as reference material, in true database software, the student can actively explore, create, manipulate, and analyze data. Data base educational software is a new genre: consequently there are as yet few exemplary programs available. Those related to geography mostly contain country and/or state demographic, political, social and economic data. The intended audience is typically high school or college. For example, *One World: Countries Database* from Active Learning Systems (1985) contains facts and statistics in 33 categories (e.g., neighboring countries, literacy rate, dominant religions, major imports/exports) for 178 nations. Multiple criteria may be constructed to probe the database. In addition, certain categories can be modified. Frequent data updates are supplied by the publisher.

An innovative spin-off of the commercially-prepared data base is introduced by *Hometown*(1986) which presents the student with a template or "empty data base," guiding the student in constructing a new data base about his/her home town. Various kinds of survey data can be collected, stored, analyzed, and printed out with this program.

Another kind of data base software, *Map Pack* (1984), contains map outlines to be manipulated and printed out. Until recently, screen resolution and computer memory were severe limiting factors: now, however, super high-resolution capabilities and larger memories have encouraged publishers to introduce more of these programs. Clearly, database software is a powerful aid to creative problem-solving (and problem-discovering) by students. A premium is placed on critical thinking skills in using these programs.

For further information on the educational applications of microcomputers in geography, see the article by Snaden (1987).

Uses Essentially Unique to Geography

Geographic applications of microcomputers include: the acquisition and display of digital data, digital image analysis, computer mapping, GIS, and statistical analysis of spatial problems. Geographers have made some contribution in these areas, and the potential for more serious involvement by geographers is real. However, we need to be more involved in software development or we may find ourselves locked out by other opportunists.

Digitizing the Land

Digitized XYZ terrain data for use on microcomputers are now available from a number of sources, and more undoubtedly will be forthcoming. Three sources of digital data are the United States Census Bureau, the Defense Mapping Agency (DMA), and the United States Geological Survey (USGS). Each of these federal agencies provide coordinate files. The Census Bureau also provides data on human activity, keyed to locations.

Three sets of USGS data files are of particular interest: the Digital Line Graph (DLG) files, the Geographic Names Information System (GNIS) Files, and Digital Elevation Model (DEM) files.

The DLG files contain "fully topologically structured data composed of three interrelated elements: node, area, and line records" (Lumen, 1987, 322). GEOVISION's *Windows on the World* already includes DLG files. GEOVISION designed its package to access data files from CD-ROM. Using CD-ROM for storage has allowed GEOVISION to place the entire United States, at the 1:2,000,000 scale, and the national GNIS file, on a single disk. GEOVISION will be releasing state level disks including the DLG-3 at 1:100,000, GNIS, Land Use/Land Cover, and Political Divisions during 1988.

GNIS files are much less complex than DLG files (USGS, 1983). The GNIS links place names found on 1:24,000 quad sheets with the latitude and longitude of the features, and thus serves primarily as a gazetteer. United States Geological Survey GNIS data files are available from the National Cartographic Information Center (NCIC) on magnetic tape for $75 per state. The ready availability of these data represent an important advance for geographic information systems (GIS) development because individual users no longer need to construct topographic data layers from scratch. Sechrist, McCully, and Taylor (1987) developed a query-based, microcomputer program that allows users to extract place names by feature class from GNIS files. GEOVISION, Inc. also uses GNIS files in conjunction with DLG files to name features in its *Windows on the World* package.

Digital Elevation Model files are constructed by systematically recording elevations at approximately 30 meter intervals in the 7.5 minute series and every three seconds of arc in the 1:250,000 series (USGS 1984). The x and y coordinates are recorded as UTM coordinates for the 7.5 minute series and as latitude and longitude for the 1:250,000 series. DEMs have been used to make the now famous poster of Mt. St. Helens, before and after the eruption. They have also been used to study the area of land covered by floods. Their main function, however, is data for the construction of elevation maps whether they be contour or 3-D. The package *Digital Terrain Analysis*, by the US Military Academy Department of Geography and Computer Science, uses DEM data to produce contour, slope, line of site, and perspective profile maps. DEM data files are available from the USGS for $100 per 7.5 minute quadrangle and $75 for 1:250,000 scale series.

Boundary Files for Census Maps & Marketing Studies

While the USGS is the sole producer of topographic files, many vendors produce boundary files for thematic mapping. Many of these files derive from a common original source, the US Census Bureau GBF/DIME files. Zip code files are another category of boundary files; however, they are generated by proximal techniques. At least two companies, Rand McNally and Geographic Data Technology, distribute these files to software vendors.

Databases

Beyond the mundane activities for which most people use databases (student records, departmental inventory, library holdings & course bibliographies, slide collections, survey responses, and data for analysis), geographers have two special database needs: cartographic databases and geographic information systems. Cartographic databases contain geocoded records with data for places. These data, usually from censuses, are stored for retrieval and linkage with cartographic software. Unlike geographic information systems which focus on map analysis, these databases focus on map display. A number of such systems have been created over the past ten years. The first, Data Information Display System (DIDS), was not very successful (Carter 1984, 38). A second system (Garson, 1986) has received poor ratings. The most recent addition to the software in this category is Supermap, which stores its census data on CD-ROM.

The Compact Disc-Read Only Memory (CD-ROM) is rapidly becoming an important mass storage medium for databases. It is a device that can hold the equivalent of 1500 5.25 inch 360K byte floppy disks. At the present time CD-ROMs and the equipment to play them is expensive, but in time prices will fall.

There are now three CD-ROMs that specifically relate to geographic applications. In addition to Chadwyck-Healey's Supermap, these are: Geovision's U.S. Atlas and the Census Bureau's Test Disks (One and Two). The Geovision system allows roaming and zooming. Supermap consists of a thematic mapping package combined with 1980 census data (2447 county and state level variables). The Census Bureau's Test Disk One includes 1982 census of Agriculture, STF-3B (five digit zipcode 1980 census twenty percent sample), and population estimates for functioning governmental units. While the Census Bureau is selling Test Disk One for $125, other companies charge more for the same data. The Census Bureau has had a long history of innovation in information processing. The Bureau is intent on keeping this tradition alive by committing itself to data dissemination on CDs for the 1990 decennial census, and the possibility for data from the 1987 economic censuses being placed on CD is still alive.

Number Crunching

Geographers frequently conduct surveys and gather data on a variety of topics. We use statistical packages to tabulate and summarize the results of our efforts. They help us to test

hypotheses. They range in complexity from shareware such as Epistat to more sophisticated commercial products. Geographers have long appreciated the strengths of SPSS (*Statistical Package for the Social Sciences*), available previously only on mainframe computers. Now, SPSS/PC+ has been developed for use on the IBM-PC and compatibles. Look for geographers to use it extensively.

Digital Satellite Image Analysis

Even a cursory glance at job listings in the "Jobs in Geography" section of the *AAG Newsletter* makes clear the huge demand for geographers with skills in remote sensing. These job opportunities have been accompanied by a rise in demand for computer software that can be used to analyze Landsat imagery.

SPEC-DAT produced one of the first digital image analysis systems, called RIPS. It consisted of a large (by microcomputer standards) modified Cromemco computer with eight inch disks, and a Panasonic RGB monitor that used connections that were unique to the system. Its operating system was a variant of the CP/M operating system. Two software packages, SPEC-DAT and RIPS (from EROS in South Dakota) provided the analysis. Later the package was altered to run on IBM microcomputers.

One of the first image analysis systems for Apple II computers was APPLEPIPS. That system was later modified for the IBM-PC, and called MICROPIPS. A public domain program, LANDSAT, will do most of what the software on those systems will do, and it is available for just one dollar from the IBM Software Exchange of the A.A.G. Microcomputer Specialty Group.

Computer Cartography

Computer mapping packages can be used to create the full spectrum of maps. Some, such as Sungeo, can even be used to produce terrain sketches and block diagrams.

The great majority of computer mapping programs run on IBM-PCs and compatibles. Only a few are available for other machines such as the Apple II, the Atari, or the Apple Macintosh. The quality of the output depends to a great extent on the specific output device used. Using a color graphics adapter with the IBM produces a monitor screen display with limited resolution and few colors from which to choose. Depending upon the program, output may also be directed to a printer (color or black and white), a plotter, or to photographic slides through devices such as the Polaroid Palette.

Geographers have a special requirement in computer mapping packages which sets them apart from most business users. While most business users are content to purchase boundary files, geographers need to be able to create their own boundary files. Only a few computer mapping packages offer this option. Among them are *Atlas*Graphics* (in combination with *Atlas*Draw*), PCMAP, *Polymaps*, and *MultiMap*. See the article by Lewis (1986) for more about computer mapping.

Geographical Information Systems

Geographical Information Systems (GIS) are, in part, a kind of electronic map. They rely on digitized landscape features. That is, X, Y (and sometimes Z) coordinates are stored in the computer for many classes of features, such as topography, wetlands, people, dwellings, property boundaries, streets, land uses, and zoning categories. A user can then electronically overlay feature one upon another to answer such questions as: How much wetland in our town is zoned for commercial business? or How many people with an annual income of more than $50,000 live within a 25 minute drive of my store? In addition, GIS can be used to find the least costly route for new highways. One might ask for a display of all routes between X and Y which satisfy these criteria: (1) maximum length 18 miles, (2) no more than 10% of the routes above 1,250 feet elevation, and (3) no more than 10% of the routes across wetlands. Further, one can ask GIS to give ground level views from any point in any direction.

Several PC-based packages with such GIS capabilities are already available. One, the *Map Analysis Package* (MAP), is available for $20 from the Harvard University Computer Graphics Laboratory. Another is IDRISI, sold by Clark University for only $70. Other more sophisticated systems, such as PC-ARCINFO, have greater capabilities, but require complex equipment and may cost up to $30,000.

Spatial Analysis

Geographers and others have developed a series of analyses designed to quantify spatial patterns and processes beyond the standard statistical methods. These techniques are well documented in the literature and have been implemented in many universities on their mainframes; unfortunately this means that each university has its own version. Similar events are occurring in the micro arena, with the exception of programs listed in two text books, Statistical Methods in Geography by David Ebdon (1985) and Microcomputer Techniques in Planning by John Ottensmann (1985).

Directions for the Future

We have reviewed where we have been and where we are. Given the short history of microcomputers, the accomplishments are impressive by any standards. By the end of the twentieth century, however, these accomplishments will appear minuscule. The development of new software systems, many fueled by the ever increasing storage capacity of systems, will continue as more people become skilled programmers and program sophistication increases. The big question is: "To what extent will geographers be active participants in the development of geographic software?" In order to be players in the game, we must intensify the training that is given to our students. The geographic curriculum of many universities has incorporated courses that prepare students to be users of geographic software, but users are not developers. Unless we become developers, geographic software will be produced by non-geographers, thereby limiting our control over content and quality.

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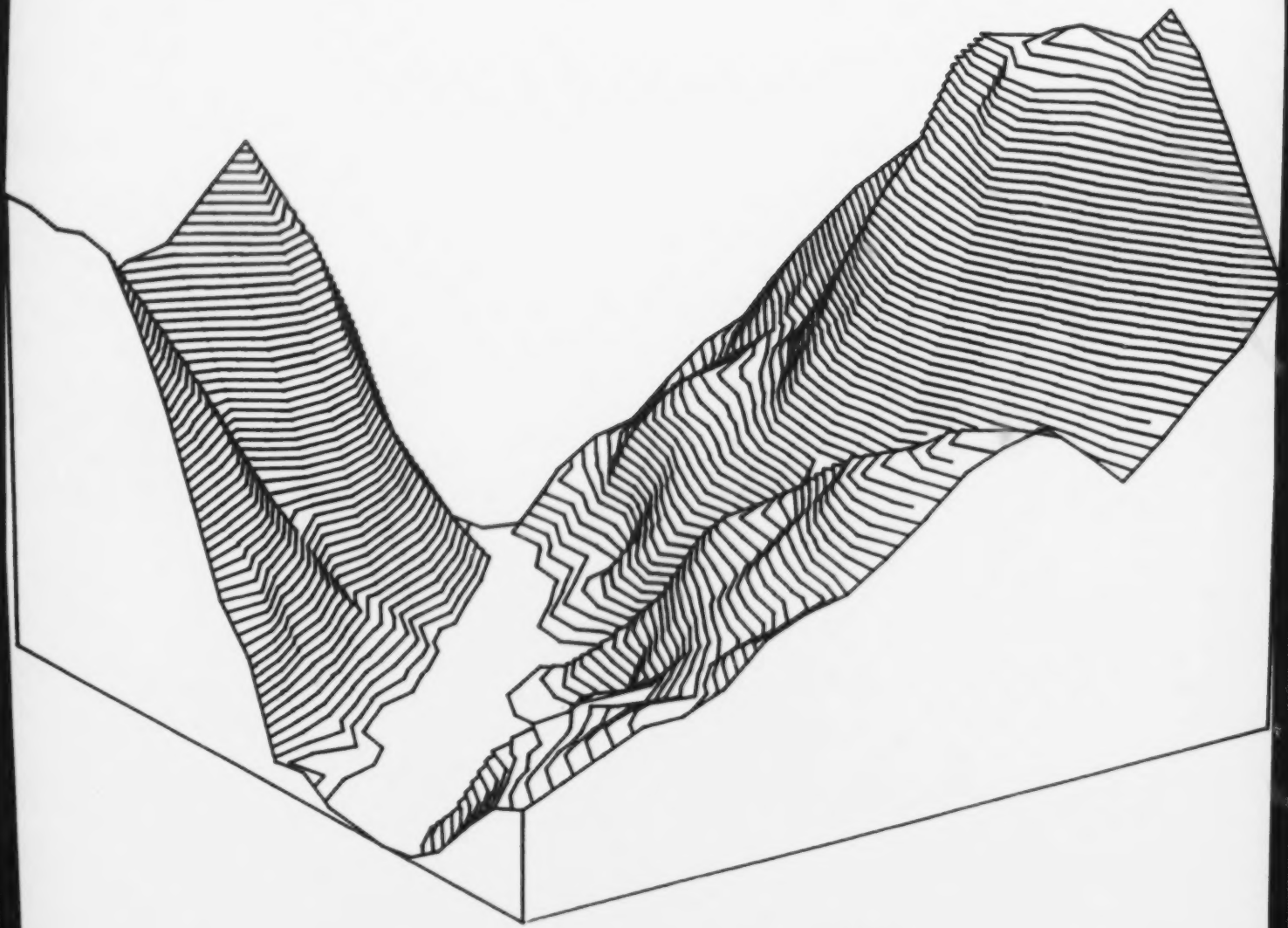
Contour Map with Irregular Shape

Surface Plot with Irregular Shape

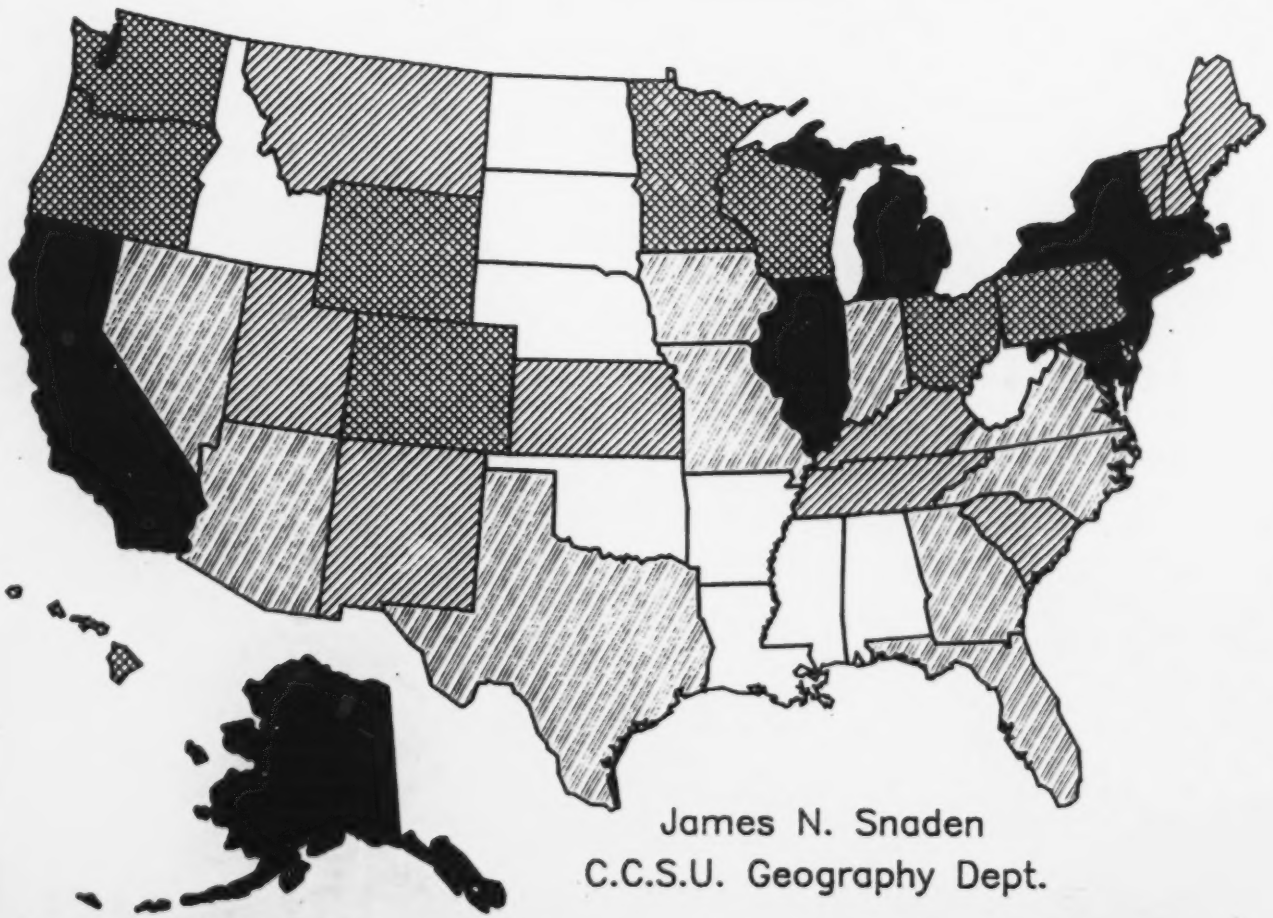


KENT FALLS STATE PARK

Average Teacher Salaries

1987 - 1988

Choropleth Map



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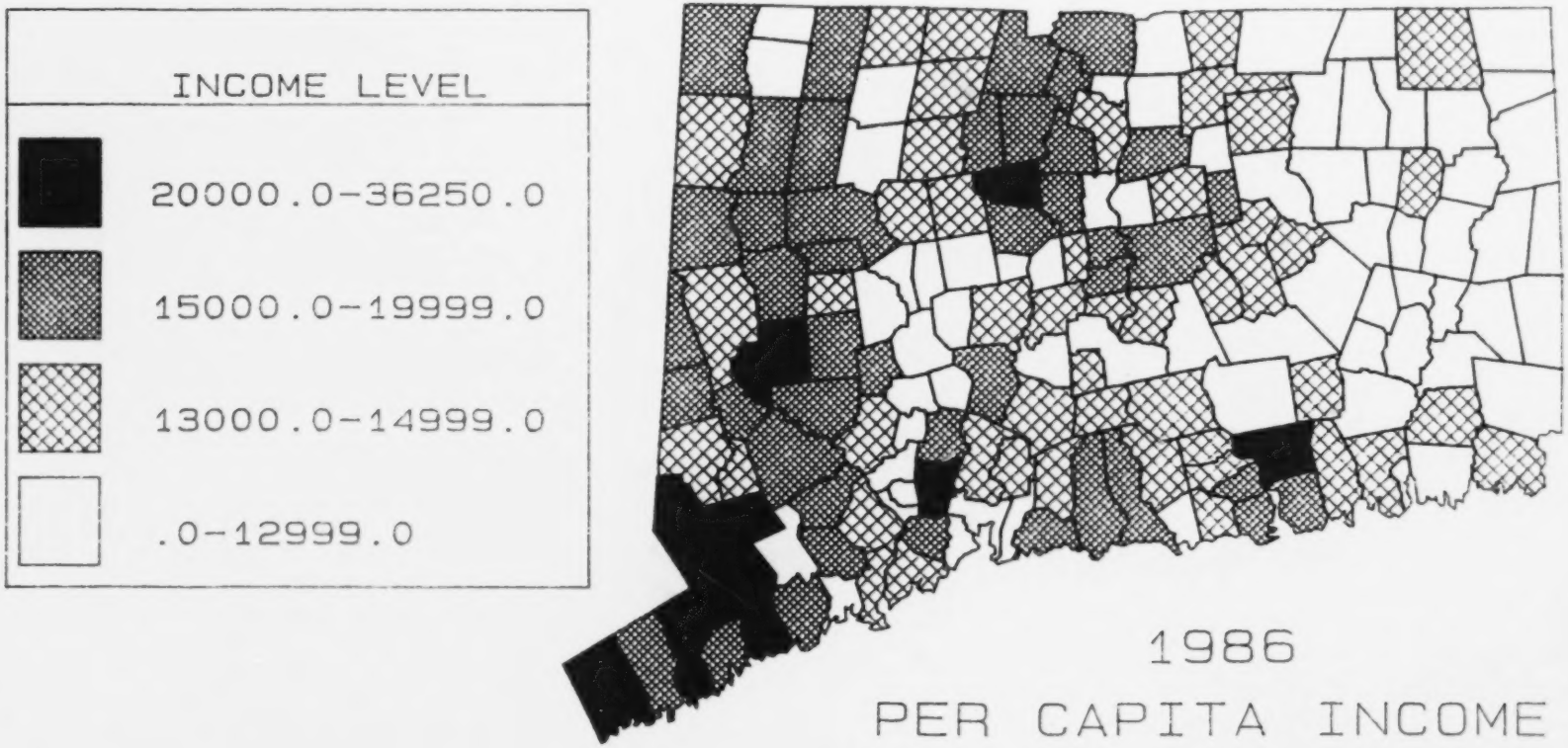
CT 1986 INCOME LEVELS



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